STORAGE ROTS AND THEIR CONTROL

by

W. M. Iritani and G. D. Easton 1/

INTRODUCTION

Storage rots occur annually and require the constant vigilance of growers for control. Although accurate estimates of weight losses in Washington are not known, 1-3% is probably a fair estimate with the occasional total loss of a storage. Affected tubers may be characterized by any of the following: (1) wet rot with a putrid or acrid odor, (2) wet and slimy rot with very little odor, (3) firm and dry rot with a slight odor, (4) dry rot which completely disintegrates, or (5) slight surface blemishes only. Most tuber rots in storage are caused by disease organisms. The environment prior to or during storage may predispose the tubers to organism infection. Factors such as stress conditions during growth, harvesting tubers from green vines, harvesting overmature tubers, bruising tubers during harvest, over irrigating to pond water in low areas in the field, and poor suberization (healing) conditions of tubers in storage may predispose tubers to late blight, bacterial soft rot, early blight tuber blemishes, pond rot and Fusarium decay.

The purpose of this paper is to describe the major storage rots, list known control methods and to discuss management practices which will minimize infection and control rots which have progressed either in the field or early in the storage period.

FUSARIUM DRY ROT

This is a fungal rot caused by Fusarium spp. from soil on the tubers. The organism enters the tuber through wounds or cuts, and rotting takes several months to develop in storage. Affected tissue varies from brown to black in color; the tissue is moist, but firm with a slightly putrid odor. (See Figures 1 & 2) The rot may become dry when most of the tuber is affected. A wet, putrid decay occurs if secondary bacterial infection occurs in the Fusarium decayed area. Losses due to this rot have not been determined in Washington, but it is questionable whether chemical control would be justified. The disease may be reduced by preventing wounding at harvest and providing conditions to promote suberization of these tuber wounds at the beginning of the storage period. Recently Mertect® was reported to control Fusarium dry rot in Maine. Mertect is being evaluated now for use in Washington.

PYTHIUM WATER ROT

This fungal rot is caused by Pythium spp. It appears for several years on storaged potatoes grown on new land and then for unknown reasons disappears. In storage it affects single isolated tubers scattered throughout the pile and does not spread to other tubers. Affected tissue is beige to a dark brown in color, firm at first, but very watery later. (See Figures 3 & 4) The odor is similar to sour milk and is never putrid, unless secondary bacteria

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1/ Horticulturist, Department of Horticulture, Washington State University, Pullman, and Plant Pathologist, Department of Plant Pathology, Washington State University, Irrigated Agriculture Research and Extension Center, Prosser, Wash.
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become involved. Later the tuber loses its moisture and becomes mumified and dry. The causal organism is attached to the epidermis (skin) of the tuber at harvest and cannot be washed away with a stream of water. Tuber infection has been prevented by a 10% Clorox® spray. The disease is named from the watery rot of affected tubers and not related to any affect of irrigation. Rate of irrigation does not affect the incidence of this disease. Tuber wounds are not necessary for infection since the organism can penetrate directly through the tuber epidermis. A low storage humidity and high temperature (60-65°F) promotes the rot which may develop in only 3-6 days. Storage temperatures of 42-45°F slowed down but did not prevent rotting by this organism. High storage humidity (90-95%) and low temperature (45-50°F) during the beginning of the storage period are recommended for control.

EARLY BLIGHT TUBER BLEMISH

This fungal disease caused by Alternaria solani produces very shallow tuber blemishes which develop after 3 to 4 months in storage. The exterior surface of these blemishes may be slightly sunken and blue to blue-gray in color. (See Figure 5) The interior of the lesion is dark brown to black, firm and extends only 1/16 to 1/8 inch from the epidermis (skin). The causal organism is contained in soil clinging to storage tubers. Infection occurs during storage and lesion development is very slow. Some years entire storages cannot be sold on the fresh market as U.S. No. 1 tubers when 5% or more by weight of tubers have blemishes over 5% of their surface. Mature, non-bruised tubers do not develop early blight blemish. For example, carefully hand dug tubers from dead vines do not develop blemishes. Experimental chemical protectants of storage tubers and storage conditions are currently being evaluated in Washington for control of early blight tuber blemishes.

LATE BLIGHT ROT

This rot is caused by the parasitic fungus, Phytophthora infestans. It developes mainly through the contamination of tubers during harvest by spores of the fungus from leaf and stem lesions of infected green plants. This rot can be difficult to distinguish between pond rot when secondary bacteria become active in the late blight rotted area and cause wet rot. Initial tuber rot consists of a brown or purplish, black metallic exterior discoloration on the epidermal surface and a reddish brown discoloration extending about one-fourth inch below the surface. (See Figure 6) Usually the epidermal area around the rot has a purplish black line of demarkation. Above 45°F, the rot may spread from tuber to tuber in storage from spores produced from rotting tubers, and entire storages can be lost to late blight. Chemically killing the vines, or allowing frost to kill the vines prior to harvest controls infection in all tubers except those near the soil surface contacted by spores in the field. Tubers suspected to be infected with P. infestans should be stored near 45°F at the beginning of the storage period and 42°F thereafter.

BACTERIAL SOFT ROTS

These rots, caused by Erwinia spp., Pseudomonas spp. and other bacteria, produce a yellow, white, tan, or brown colored decay with a soft, wet or slimy consistence and a putrid odor. (See Figure 7) Causal organisms may occur in normal healthy tissue and also in soil attached to stored tubers. Usually initial rot areas develop from tuber wounds. The bacterial soft rot organisms also produce secondary rot in rotted tissue caused by other fungal organisms. Sub-oxygen conditions, wet tuber surfaces (cellar sweating), and temperatures above 45°F enhance tuber rot by these organisms. Bacterial soft rot is controlled by reducing bruising during harvest and piling, maintaining suberizing storage conditions at the beginning of the storage period and temperatures of 42-45°F after, and adequate air ventilation during the entire storage period.

RING ROT

Ring rot, caused by the bacteria Corynebacterium sepedonicum invades tubers systemically via the stolons of infected plants. The internal ring of xylem bundles (ring) of an infected tuber cut near the stem end may appear symptomless, light yellow, or brownish in color. The ring will usually separate and exude a creamy ooze when the tuber is squeezed. Large cavities may also develop internally near the tuber ring. (See Figure 8) Sometimes, especially in the Norgold Russet variety, external gray to black areas develop on the sides of the tuber. Later these affected side areas dry and become brown and corky. Usually, severely infected tubers will rot in the field and disappear before harvest. Obviously, the best control practice is not to store tubers from a ring rot field. However sometimes early marketing is not possible. Delaying storage until very late in the fall after the severely infected tubers have rotted in the ground and selling storages with ring rot first are also helpful.

The initial storage temperatures should be kept no higher than 45-50^{o}F, and be lowered after several weeks to 42^{o}F to keep slightly infected tubers from rotting.

POND ROT

Tubers are usually affected on one end or side which was exposed to ponded water; however, the entire tuber may be involved. The tuber surfaces are dull gray or brown, not sunken, and usually have only a slight demarkation between damaged and healthy tissue. Internal diseased tissue (3/4 to 1 inch in depth) is initially firm, reddish brown and irregular in shape (See Figures 9 & 10) The diseased tissue becomes soft and watery and a putrid acrid odor becomes noticeable. After several months' storage, depending upon temperature, the tuber pile shrinks and a trickle of water flows underneath the storage. Rot is initiated in the field prior to harvest in swales where water has ponded.

Thus far we have not been able to isolate an aerobic disease organism from affected tissue. This rot is controlled by applying cultural practices which prevent ponding. Practices which may be effective are reducing the slope of swales, applying "dam pitting" to potato furrows at last cultivation, and effective management of irrigation water. Of course, any affected tubers from these ponded areas should never be stored. A storage temperature of 45^{o}F will slow but not prevent pond rot.

STORAGE MANAGEMENT TO PREVENT AND CONTROL ROT DEVELOPMENT

Ventilation, temperature, and humidification are factors or conditions in storage which should be controlled to prevent or impede the progress of rot development. Proper management of these factors can mean a profit or complete loss due to rot development.

VENTILATION

Ventilation controls rot because it is the mechanism by which temperature control is attained. Rot progression is slowed considerably by lowering temperatures as indicated by Figure 11. The present recommendation is to cool potatoes as rapidly as possible to curing or suberizing temperatures of 50^{o}F. In Washington, a ventilation rate of at least 17 cfm is recommended since ambient nocturnal temperatures for cooling are slightly higher than most of Idaho. Ducts not being used can be closed during early filling of storages to concentrate larger amounts of air through potatoes harvested early.

Ventilation also prevents accumulation of CO_2 and provides a constant supply of oxygen which is essential to rapid suberization and maturation of tubers. Anaerobic conditions as caused by high CO_2 accumulation enhances development of some bacterial rots. Proper ventilation also provides uniformity of temperature in the pile which prevents excessive weight loss. Free movement of air controls condensation or free water on tubers which enhances rot development. Wet areas on piled potatoes should be avoided by constant ventilation. Hot spots or areas of rot acticity can be controlled from spreading by forcing increased amounts of cool dry air through that portion of the pile. Condensation from the ceiling can be controlled by adding an additional layer of insulation or applying thicker layers to thin areas on exposed beams and rough areas of the ceiling. Blowing air across the ceiling will also help cut down on condensation.

TEMPERATURE MANAGEMENT

As previously indicated, field or latent heat in tubers should be removed as rapidly as possible after tubers are placed in storage. Tubers with pulp temperatures above 60°F should probably not be harvested because of difficulty in cooling. A temperature of approximately 50°F appears to be sufficiently high for suberization and maturation of tubers while sufficiently low to retard progress of most storage rots. These temperatures should be maintained between 2 and 3 months, and then gradually brought down to holding temperatures of around 45°F. Preliminary research data indicate that potatoes cooled too fast (See Figure 12) will develop more rot than those held at 48°F for a longer period of time. The reason for this is lack of suberization at the lower temperatures.

HUMIDIFICATION

Contrary to the thinking of many people, low rather than high humidity in storages will cause greater rot development (See Figure 12). High humidity is required for suberization and maturation.

The air washer type humidifier which recirculates large volumes of water in a chamber through which air is passed has been found to be the most satisfactory. Essentially 100% RH is obtained with this type of humidifier regardless of RH of the air entering the chamber. Additional benefits of significant evaporative cooling to remove tuber heat at harvest can be obtained depending upon the RH of the air entering the chamber. This system has very low maintenance requirements. If condensation becomes a problem as outside temperatures get cold, humidification should be cut back. Generally tubers are able to withstand lower humidities without danger of rot infection or undue amount of weight loss after several months' storage, when suberization and maturation has been fairly well completed. However, it is desirable to maintain as high humidity as possible without appreciable amounts of condensation.

If wet areas or watery type rots appear on the pile surface of stored potatoes after 2 to 3 week's storage and these areas begin to spread, humidification should be discontinued and ventilation increased until the wet areas are dried up. After the progress of rot has been controlled by drying then humidification can be resumed.

Figure 1. External dry rotting of tuber from storage caused by Fusarium spp. fungi.

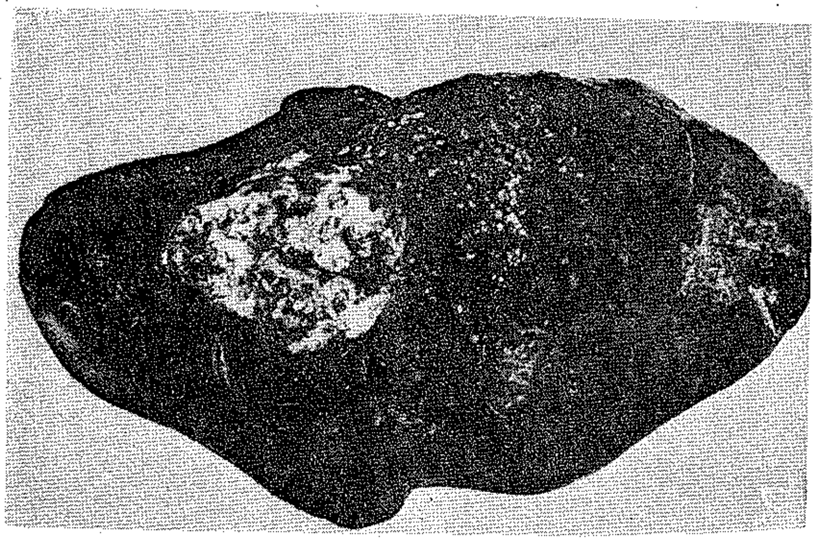


Figure 2. Internal dry rotting of tuber from storage caused by Fusarium spp. fungi.

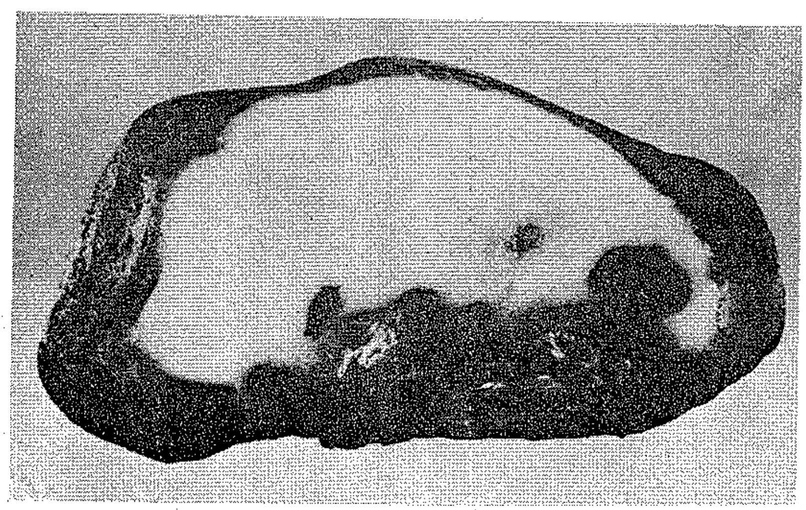


Figure 3. External dark browning of tuber from storage with water rot caused by Pythium spp. fungi.

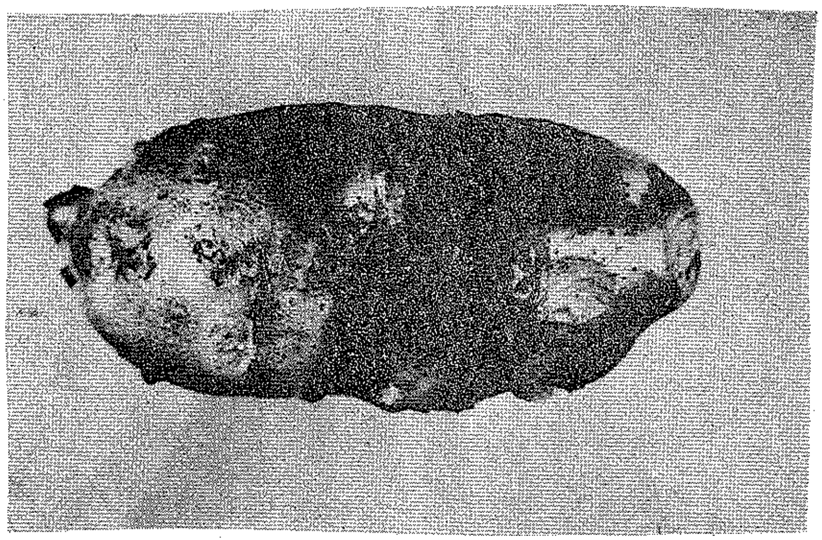


Figure 4. Internal dark browning of tuber from storage with water rot caused by Pythium spp. fungi.

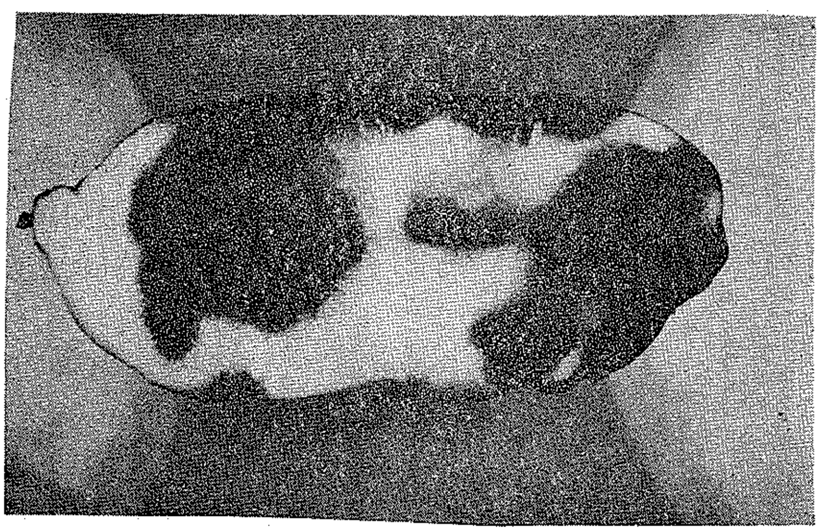


Figure 5. Brown, sunken tuber blemishes of tuber from storage caused by the early blight fungus. Blemishes enlarged 5 times.

Figure 6. Tuber from storage with brown rotted sunken areas showing distinct lines of demarkation between rotted and healthy tissue. Caused by the late blight fungus, Phytophthora infestans.

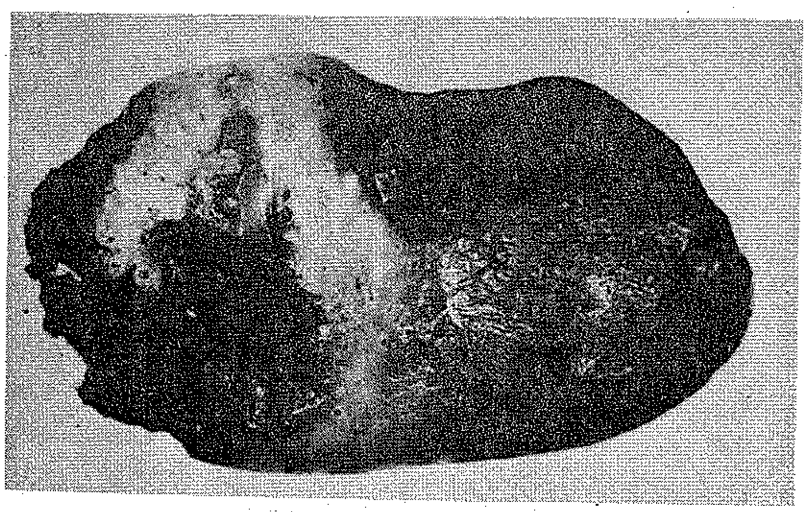


Figure 7. External slimy soft rotting of potato tubers from storage caused by various bacterial pathogens.

Figure 8. Cross-sections of a tuber from storage showing rotting in cavities in xylem ring. Caused by Corynebacterium sepedonicum bacteria.

Figure 9. Internal reddish browning of a tuber with pond rot from storage. Caused by water ponding over tubers in the field in late fall.

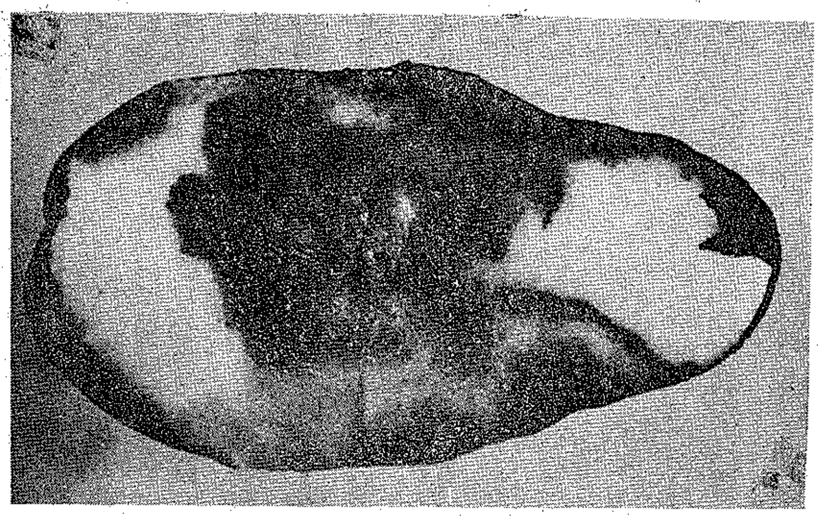


Figure 10. Cross-section with internal reddish brown areas of a tuber with pond rot from storage.

Figure 11.

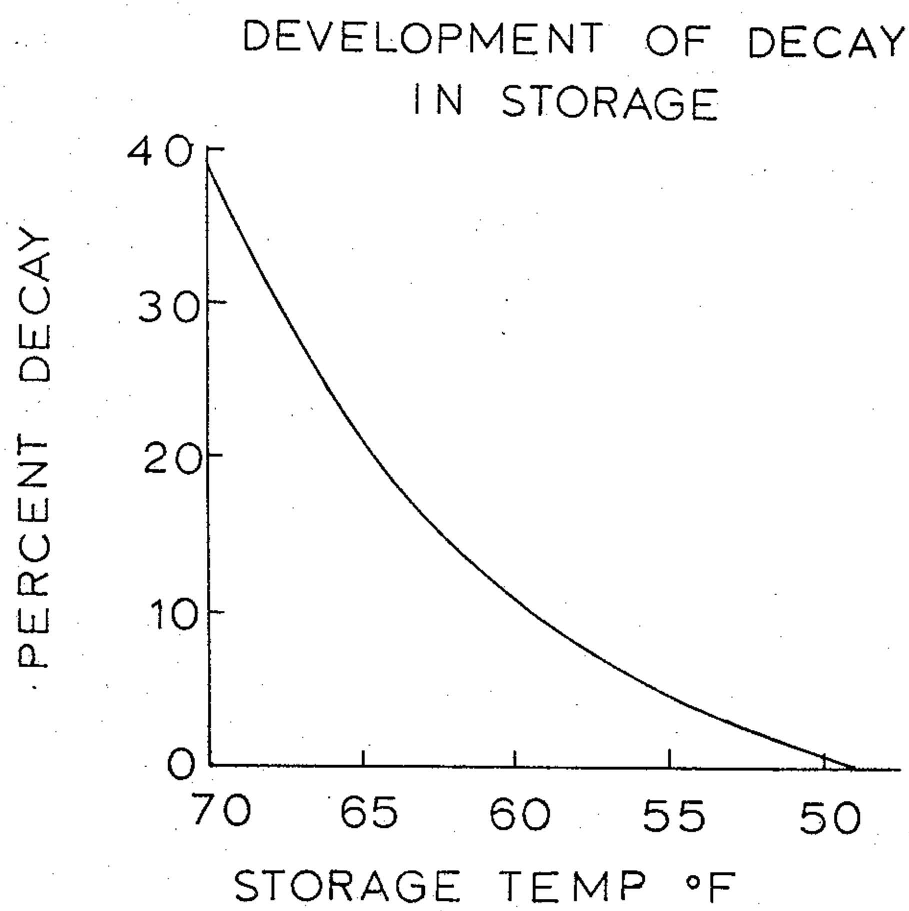
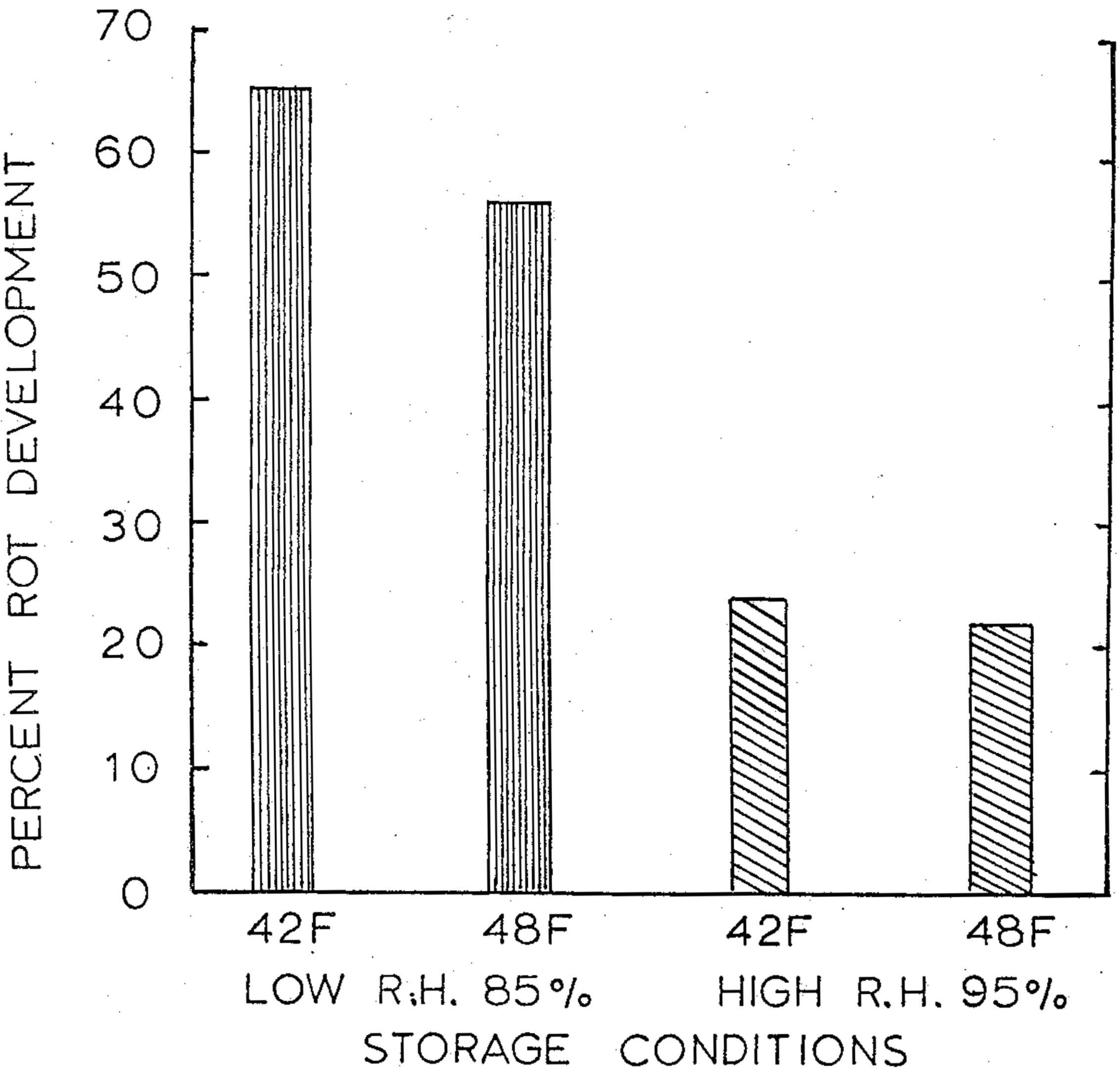

DEVELOPMENT OF DECAY
IN STORAGE
PERCENT DECAY
40
30
20
10
0
70
65
60
55
50
STORAGE TEMP °F

Figure 12.



PERCENT ROT DEVELOPMENT
70
60
50
40
30
20
10
0
42F
48F
42F
48F
LOW R.H. 85%
HIGH R.H. 95%
STORAGE CONDITIONS